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NUMERICAL SIMULATION AND COMPARISON OF 3-D TRIANGULAR & RECTANGULAR FINNED TUBE BANK

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ABSTRACT

In this study, the heat transfer and flow characteristics of triangular and rectangular finned tube bank were investigated numerically. The performance of triangular and rectangular finned tube bank was compared. The effects of fin height (1mm, 1.25mm and 1.5mm) on pressure and velocity of air and nitrogen liquid flows were studied to analyze which flow or model can increase the heat transfer coefficient of the finned tube heat exchanger. In this research, rectangular fins and triangular fins were designed by using cad tool creo-2.0 and then performed flow analysis on both models by using CAE tool (Ansys fluent). Hence it can be concluded that the triangular 1mm fin with nitrogen liquid is better than other to enhance the performance of the model.

KEYWORDS: 3-D Finned Tube Bank, Heat Exchanger & Numerical Investigation

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Original Article

INTRODUCTION

In the recent years, the energy (heat) utilization has been increased spontaneously. Meanwhile the wastage of energy (heat) was also increased randomly. In this scenario, the main aim of this research is that the amount of energy has been utilized as much as possible, for this, heat exchangers are mostly helpful. To increase energy utilization competence, it is mandatory to expand modern energy (heat) utilization technical knowledge, e.g. finned tube heat exchangers including high heat function. There is multiple numbers of methods to increase the transfer of heat in a heat exchanger [1–10]. Heat exchanger is mostly useful for energy usage, and has been extensively used in central air (AC), chilling, heating system, and the chemical (fuels) factories due to high heat transfer coefficient [1]. There are mainly two types of finned tube heat exchangers. They are (3D) discrete three dimensional finned tube banks and (2D) continuous two dimensional finned tube banks heat exchanger. 3D discrete finned tube has higher performance on the improvement of heat transfer than the 2D. Particularly, from the 3D discrete fins, such as (rectangular, parabolic) the interrelation among the transfer of heat and flow characteristics of the various finned tube geometries were conducted to conclude by multiple investigations and theoretical studies. For example, spiral fin [2, 3], plane fin [5, 7], lowered fin [13, 14]. If the fin pitch, fin height, tube row spacing and tube rows number have been decreasing then the heat transfer coefficient increases [17-19]. One of the characteristics of the fins is vortex generators. It also increases the heat transfer coefficient of the fins [11-12]. The fin pitch is more effective on friction factor than the Colbourn factor, were determined experimentally by song et al. [11]. ZHAO et al. [12] showed that the optimized H-type finned tube in an oval tube bank exchanger is demonstrated for more performance on both anti-wear and heat transfer. The above mentioned reporters reported that finned tubes, in this study, more part of the effort was concentrated on exploring the performance of heat transfer of finned tubes that were designed using tube expansion technology. These types of finned tubes are generated on a heat contact resistance at an

interface of the fins. Recently, fins arrangements and technical knowledge of manufacturing, production improvement become more intricate. In this scenario, (3D) three dimensional finned tubes are playing a vital role. 3D finned tubes are small sections from straightly trim the side of the metal tube using of cutting tools. Reporters were studied on 3D finned tube heat exchangers [20, 30]. The continuous 2D micro finned tube compared with 3D micro finned tube has given a less heat transfer coefficient been reported in HONDA et al. [22]. R. Sajedi and Wu [20-21] reported that the number of fins and height of the fins gave the considerable reaction on the transfer of heat. In the heat transfer field over a century extended surfaces have been used, but in recent situation the usage of 3D fins have been increased more for one past decade, high effective heat transfer sections with low weight, low cost and low volume for most industries are required. Based on the space cost and space availability various configurations of fins are used in future, this information is wrathful. Li and Liao [27-30] investigation ally decided by using 3D fins on the inside wall could be considerably decreased the tubes of inner thermal resistance.

Table 1: The Thermal Performance of the Heat Exchangers with Wave Fins of Previous Experimental Investigations

Investigator	Wave Pattern	D_o (mm)	P_f(mm)	P_t(mm)	P_l(mm)	N	X_f(mm)	P_d(mm)	α (deg)
Goldstein & Sparrow(1976)	H*	8.53	1.65	21.3	N/A	1.0	4.63	1.78	21.0
Beecher & Fagan(1987)	H	7.94-12.7	2.08-7.97	25.4-31.8	22-27.5	3.0	2.76-5.50	0.97-3.18	10.0-34.7
wang etal, (1997)	H	10.3	3.53	25.4	19.05	1,2,3,4	4.76	1.5	17.5
wang etal, (1998)	H	8.54	1.21-2.54	25.4	19.05	1,2,4	4.76	1.32	15.5
wanget al, (1999a)	H	13.6-16.9	3.04-6.45	31.8-38.1	27.5, 33	1,2,4,6	6.88, 8.25	1.8	12.3. 14.7
wang et al, (1999b)	H	8.62	1.68-3.17	25.4	19.05	2,4	4.76	1.18-1.58	14.9-18.4
SaizJabardo et al. (2006)	H	12.7	1.81-3.17	31.75	27.5	1,2,3,4	5.5	1.83	18.4
Mirth & Ram-dhyani (1994)	S	13.2, 16.4	3.12-6.15	31.8, 38.1		4,8	6.875	2.38, 3.25	19.1–25.3
Kim et al. (2004)	S	10.3	1.3-1.7	25.4	21.65	1,2,3	5.41	1.5. 2.0	15.5, 20.3

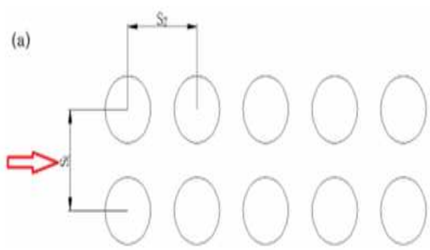
Most of the reporters are investigated on 3D fins. There are rectangular, pin and parabolic fin, the configuration of these types of fins is near to streamline compared with 3D triangular fin. This is the general knowledge that the stream line type fin is not better to the fluid disturbance increases. So, this is acceptable that the 3D triangular finned tube heat exchanger will give good heat transfer conducted. Journalist knowledge, few reporters were reported on 3D triangular-finned-tube heat exchanger. In addition to that, the multiple studies reported on 3D finned tubes are completed by the use of critical and costly analysis. Comparing with Numerical simulation, experimental studies have alternative techniques for getting into depth knowledge of flows and heat distribution and their reactions on the pressure drop. In this matter, the major aim in this study is to get the mechanism of heat transfer in 3D finned tube bank with various configurations to reach the more capable heat exchanger to expand the transfer of heat. Inspect on the effects of velocity distribution with air and liquid nitrogen flows and also comparing the 3D rectangular finned tube values with the triangular finned tube bank.

PROBLEM DESCRIPTION AND MATHEMATICAL MODEL

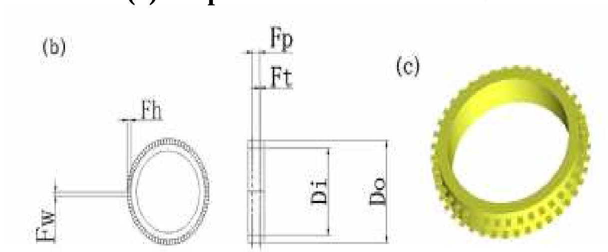
Physical Model

The following diagram shows the shape of circular tube bank with five rows (Figure 1(a)). Liquid nitrogen and air flows across the tube bank in a required shape beside in the direction of X. The following diagram Figure 1(b) and (c) shows

reciprocally the characteristics of geometric models and the construction of 3D triangular finned tube bank. In this model the full form of F_h, F_w, F_p, D_o, D_i, S1, and S2 are height of fin, width of fin, pitch of fin, outer dia, inner dia, tube pitch of transverse and tube pitch of longitudinal. The fin distributions are uniform beside with perimeter and they were instability beside the direction of Z. The below given Table 2 shows that the geometrical variables of the primary 3D rectangular and 3D triangular finned tube bank.



(a) Shape of Finned Tube Bank.



(b) Finned Tube Geometrical Definition. (c) Three Dimensional Finned Tube.

Figure 1: Simplified of Shapes of Tube Bank and Finned Tube Geometrical Definition.

Table 2: Finned Tube Bank Geometric Parameters (Five Rows)

Parameters	Type of Heat Exchanger	
	Rectangular	Triangular
Row numbers (in flow direction)	5	5
Arrangement of tube	Staggered	Staggered
Material of tube	Al	Al
Material of fin	Cu	Cu
Tube Row Spacing (S_2)	97.5 mm	97.5 mm
Transverse tube pitch (S_1)	97.5 mm	97.5 mm
Thickness of the fin (F_t)	0.2 mm	0.2 mm
Fin pitch (F_p)	1 mm	1mm
Innerdia(D_i)	36mm	36 mm
outerdia(D_o)	40mm	40mm
Fin height (F_h)	1 mm	1 mm
Fin width (F_W)	0.5 mm	0.5 mm
S_1/D_O	2.4 mm	2.4 mm
S_2/D_O	2.4 mm	2.4 mm
F_h/D_o	0.025mm	0.025 mm
F_w/D_o	0.0125mm	0.0125 mm
F_P/D_o	0.025 mm	0.025 mm

Governing Equations

Let us consider a three dimensional, viscous, steady, incompressible turbulent flow, and the air substantial properties are constant in the air flow in the heat exchanger. Tubes are made with aluminum and fins are made of copper with constant thermal conductivity. The finned tube inside the wall surface has estimated the temperature is constant at Tw = 313 K. The air governing equations are momentum equation, mass and energy conservation equations (31), these are mentioned below.

Continuity equation

$$\frac{\partial u_i}{\partial x_j} = 0 \tag{1}$$

Momentum equation

$$\frac{\partial}{\partial x_j}\left(\rho u_i u_j\right) = \frac{\partial p}{\partial x_j} + \frac{\partial}{\partial x_j}\left(\eta \frac{\partial u_i}{\partial x_j}\right) \tag{2}$$

Energy equation:

$$u_j \frac{\partial T}{\partial x_j} = \frac{\partial}{\partial x_j}\left[\frac{1}{\rho}\left(\frac{\eta}{Pr} + \frac{\eta_t}{Pr_t}\right)\frac{\partial T}{\partial x_j}\right] \tag{3}$$

where u_i and u_j are the velocity parts are in the guidelines of the i and j reciprocally, x_i, and x_j are the dimensional correlations, respectively, temperature of gas T, and density of gas ρ, dynamic viscosity is η, static pressure is p, turbulent Prandtl number is Prt, local Prandtl number is Pr, and turbulent kinematic viscosity is ηt are respectively. In this paper for the turbulence method, Spalding (32) and Launder were chosen the standard k-Ɛ model. The rate of dissipation Ɛ and the turbulence kinetic energy k are getting from the below transport equations.

Kinetic energy equation:

$$u_j \frac{\partial K}{\partial x_j} = \frac{\partial}{\partial x_j}\left[\left(\eta + \frac{\eta_t}{\sigma_k}\right)\frac{\partial K}{\partial x_j}\right] + G_k - \varepsilon \tag{4}$$

Kinetic energy-dissipation rate equation:

$$u_j \frac{\partial \varepsilon}{\partial x_j}(\varepsilon u_i) = \frac{\partial}{\partial x_j}\left[\left(\eta + \frac{\eta_t}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_j}\right] + C_{1\varepsilon} G_K \frac{\varepsilon}{K} - C_{2\varepsilon}\frac{\varepsilon^2}{K} \tag{5}$$

Where $C1_\varepsilon$ and $C2_\varepsilon$ are constants, Gk shows the turbulence kinetic energy generation caused by gradients of mean velocity and σε is the Prandtl number for Ɛ, σk is turbulent number for k, respectively.

Boundary Conditions

Figure 2 shows that the computing domain has 8 bounds outlet pressure and inlet velocity, 2 walls edges and 2 periodical edges, for maintaining of a systematic velocity and omitting the outlet free flow is re-circulating, computing domain is expanded 3 times tube diameter length in the way of upstream and 7 times tube diameter length in the way of downstream at the inlet and outlet zone. A systematic temperature Tin (423K) among the way of X air enters the computing domain at the inlet.

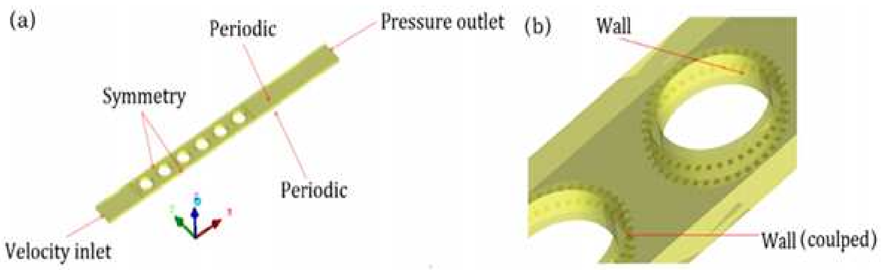


Figure 2: Finned Tube Boundary Conditions of Computing Domain and Wall.
(a) Computational Domain of Boundary Conditions
(b) Finned Tube Boundary Conditions of Wall.

Parameters Explanations

Various performance and geometric conditions, non-dimensional parameters and some characteristics of triangular finned tube bank have more accurate performance than the rectangular.

Explanations are given below:

$$Re = \frac{u_m D}{\eta}, h = \frac{Q}{\Delta T A_P}, Nu = \frac{hD}{\lambda}, \Delta T = \frac{(T_{in}-t_{wo})-(T_{out}-T_{WO})}{ln((T_{in}-t_{wo})/(T_{out}-T_{WO}))} f = \frac{2\Delta P A_m}{\rho u_{m^2} A_P}, \Delta P = P_{in} - P_{out},$$

$$PEC = \frac{Nu/Nu_0}{(f/f_0)^{1/3}} \quad (6)$$

In this report convective heat transfer coefficient is h, the characteristic length is D, Re is the Reynolds number which are equal to Do, The median velocity is u_m in the minimum cross section of the flow, the tube total surface area is Ap, PECit is a parameter of comprehensive universal thermal evaluation and above the computing domain total pressure drop is ΔP decreases, this is the flow loss and the transfer of heat increases are taking into account, shows that the difference between the multi tube exchangers of smooth and artificial rough surface, then the heat transfer capability ratio equal pumping(33), f_0 is the factor of friction and Nu_0 is the Nusselt number, reciprocally, in this study comparing the 3D rectangular finned tub bank with 3D triangular finned tube bank.

Numerical Procedure for Solution Methods

By using governing equations we can solve 3D rectangular-finned tube bank and 3D triangular finned tube bank theoretically, after that solved those 3D finned tube banks by CFD ANSYS Fluent software is used, it is depend on the finite volume method. Using of ANSYS Fluent software to do simulation, which will give the best efficiency and develop concurrence, to resolve the velocity and pressure field by the SIMPLE algorithms was selected. Pressure terms are used for the standard discritization scheme and the divergence and convection terms are used for the second order up wind discretization schemes. The energy equation residual was smaller than 10^{-6} due to all simulations is set in convergent criteria and also alternative equations are smaller than 10^{-5}.

Design of Finned Tube Bank Models

For designing purpose, creo-2.0 tool was used as per the standard dimensions. And for the analysis purpose, ANSYS fluent computational-fluid-dynamics software was used; firstly CAD model was designed in the creo-2.0 tool then exported that CAD model into ANSYS fluent software. CREO application product development serves an unique purpose. Hence, CREO software concept development, designing and analysis designs and its every aspect can be handled. Your communications with your clients, manufacturers or technical publication are supporting.

The table 3 shows the finned tube parameters of the 3D rectangular and 3D triangular finned tube bank.

Table 3: Finned Tube Dimension

Parameters	Size
Length	450 mm
Width	80 mm
Thickness	6 mm
Diameter tube	40 mm
Total No. of tubes	5 Numbers
Fins lengths	1mm , 1.25 mm ,1.5 mm

MODEL PROCESS STEP BY STEP

Designing of the 3D rectangular and 3D triangular finned tube bank have been done by using some sequence of steps, those are included in the CAD tool.

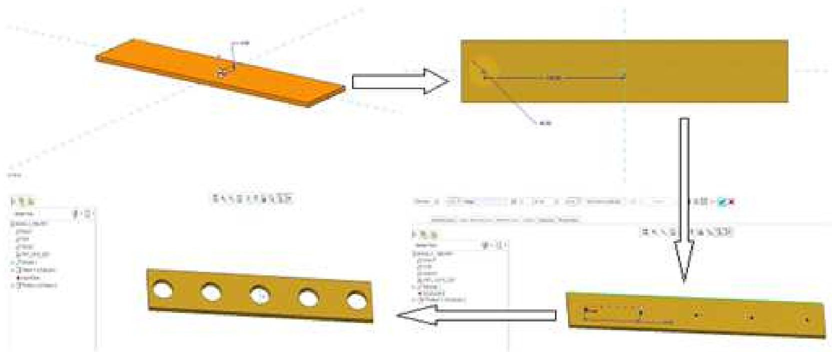


Figure 3 (a): Designing Sequence of Finned Tube Ban.

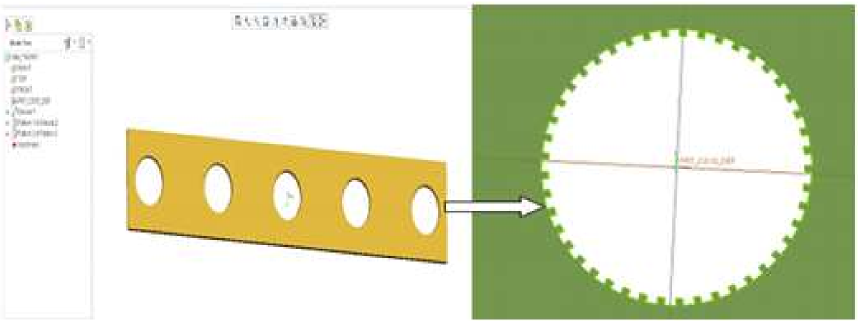


Figure 3 (b): Model of 3D Rectangular Finned Tube Bank.

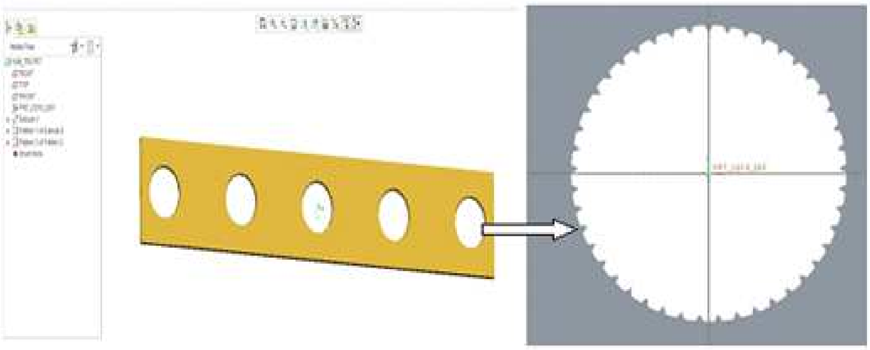


Figure 3 (c): Model of 3D Triangular Finned Tube Bank.

Figure 3(a) shows the creation of the tube with 6 mm thickness and those parameters are given in the table 3 , according to that holes have been created on the finned tube and this was done by using creo-2.0 by selecting the extrude cut option. Figure 3 (b) and (c) shows that the designing of the 3D triangular and rectangular finned tube bank, respectively. These models are further used for flow analysis and accurate result.

VALIDATION OF THE GRID AND GENERATION AND INDEPENDENCE OF THE GRID

Staggered Grid Generation

Figure 4 represents the 3D rectangular and triangular finned tube banks meshing. In this entire computational domain meshes have majorly 3 sections, those are the inlet, middle and outlet zone. For identification purpose of each zone,

applied different mesh shapes. A structured hexahedral mesh was applied to the inlet zone and outlet zone, as shown in the Figure 4(b) and (c), in the middle zone disorganized tetrahedral mesh is applied as shown in the Figure 4 (e), at this zone the interface of the 3D finned tube bank and the fluid (air and liquid nitrogen) has been irregular and complicated. However, in the tube wall area applying a good finer tetrahedral mesh to get conforming the computational accuracy as shown in Figure 4(d).

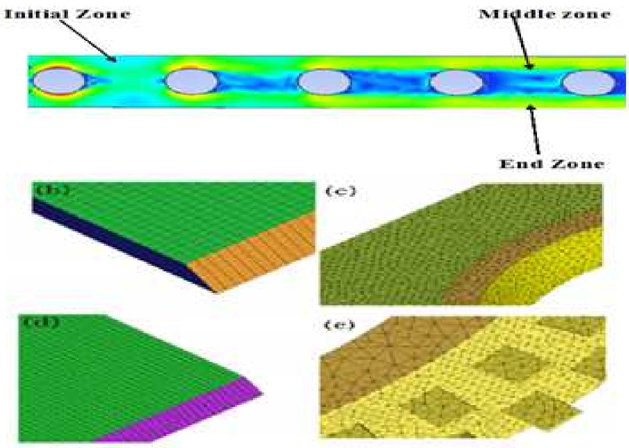


Figure 4: Pattern of Computational Grid
(a) Total Domain Mesh (b) Mesh Section of Inlet Zone (c) Mesh Section of Middle Zone (d) Mesh Section of Outlet Zone (e) Mesh Section of Finned Tube.

Validation of the Model Y+ and Independence of Grid

It is observed exactly that the modeling in the near wall continuously effect the numerical simulations of loyalty, so that, an exact wall function has to be chosen for this solutions. As reported that, for the Turbulence model the Standard k-Ɛ model is chosen. “Enhanced Wall Treatment (EWT)” for the Ɛ-equation is denoted that y+ requires for the usage of the wall performance EWT, it is from the wall to centroid of beside mesh and the non dimensionless distance is must be less than 45. This study reported that y+ value has been taken less than 3.5, it very clear that the wall near the mesh size is in the acceptable scope. The good accuracy of the numerical results has been occurred by using a grid independence test. Figure 5 indicates that we have done the Grid Independence test of primary geometry model. Four sets of Cells and Grid numbers were investigated, they are (490,458), (577, 700), and (698, 901), (806,905). After that we got the Nusselt number values at Re = 4000 are 44.93, 45.03 and 45.76, 45.70. Among the number 4 and 3 Nussult analogous error is 0.131%. Finally, we selected grid number (698,901) cells, while selecting the grid number we were compared both the computer results and the numerical results accuracy. In addition, an independence test of grid has been performed for both 3D rectangular and 3D triangular finned tube bank cases as indicated in Table 1. For good Grid independence test results, different types of grid numbers have been taken from the different geometry models.

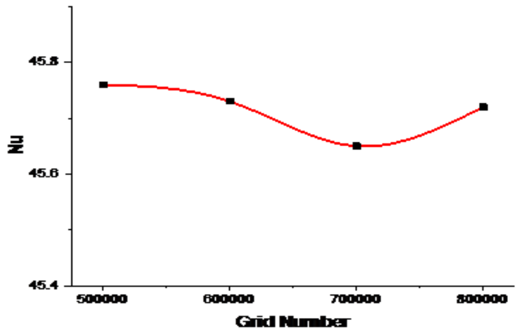


Figure 5: Nusselt Number Versus Grid Number.

Model Verification

The simulation results are to conform the accuracy in this research, it is very critical to clarify the solve method and model correctness, from there no reporters were reported about the experimental data for the 3D rectangular and 3D triangular finned tube. So that, 3D rectangular finned tube bank has been employed for the validation. This 3D rectangular finned tube bank has equal Geometric Parameters, which was already tested the 3D rectangular finned tube bank in the previous study [36]. From the studies Lu [3] and Zhukauskas [34], the experimental correlations of Nu are given below.

The Correlation of Lu [3]:

$$\mathbf{Nu = 0.326\,Re^{0.593}Pr^{0.36}\left(\frac{S_1}{D_O}\right)^{-0.18}\left(\frac{S_2}{D_O}\right)^{0.34}} \quad (7)$$

The Correlation of Zhukauskkas [34]:

$$\mathbf{Nu = 0.27\,Re^{0.63}Pr_f^{\;0.36}\left(\frac{Pr_f}{Pr_w}\right)^{0.25}} \quad (8)$$

When S1/DO= 2.4 the velocity at inlet is 2–2.50 m/s, correlating Re is 5000–10000. From Figure 6 it clearly shows the Experimental correlations and the comparison of the Numerical results. From the Experimental Correlation of Lu [3] and Numerical calculation Nu, the Nu values among the average and maximum discrepancy commonly are 2.49% and 5.66%. When experimental correlation results of Zhukauskas's [34] compare with those values, the maximum discrepancy is 4.16% and the average discrepancy is 1.87%. Among the Experimental Correlation result and Numerical calculation the best agreement mentioned that the present solution method of Numerical can loyally expected the flow and transfer of heat characteristics of 3D rectangular and 3D triangular finned tube bank.

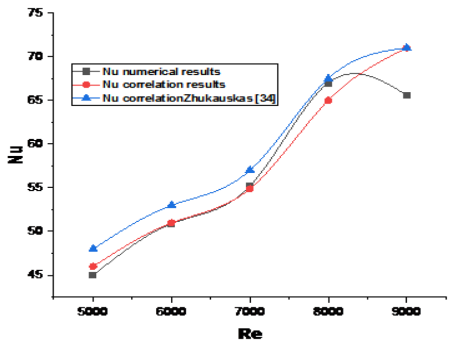
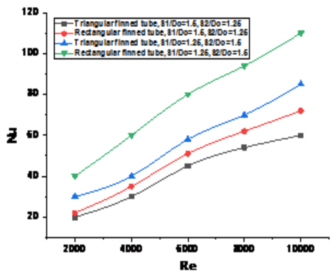


Figure 6: Numerical Results Comparison and Experimental Correlations.

COMPUTATIONAL RESULTS AND DISCUSSIONS

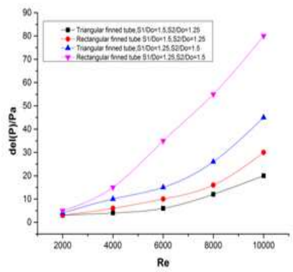
Rectangular and Triangular Finned Tube Bank Comparison

In this research, to validate the improvement of the 3D triangular finned tube bank above the 3D rectangular finned tube bank by the equal cases, first we have done the comparison between the 3D rectangular and 3D triangular finned tube bank. The fin pitch, tube row numbers, axial direction fin pitch, height of fin, of the finned tube bank are same in this comparison. PEC versus the Re number, and the diversities of the pressure drop, Nu number, Friction factor are showed in Figure 7. The various values of Re, Nu, ΔP, F values of 3D triangular finned tube bank are less over the 3D Rectangular finned tube banks are represented in Figure 7(a)-(c). Close to the wall surface of the turbulence intensity increases to a few extent, primarily cause by it's 3D triangular finned tube bank. And also, the friction loss and transfer of heat of 3D triangular finned tube bank were larger over than the 3D rectangular finned tube banks. In this report, the results show that the 3D triangular finned tube bank of transfer of heat and friction loss both were larger over than the 3D rectangular finned tube bank.



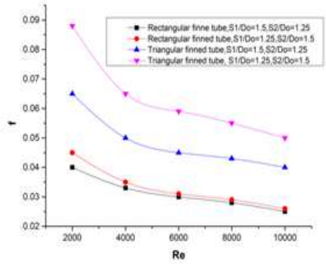
(a) Nu

Figure 7 (a): Graph of Re Vs. Nu.



(b) ΔP

Figure7 (b): Graph of Δp Vs. Δp/Pa.



(c) *f*

Figure7 (c): Graph of Re Vs f.

Analysis ff 3D Rectangular and Triangular Finned Tube Banks

For the analysis of 3D rectangular finned tube bank and 3D triangular finned tube bank we have used air and liquid nitrogen fluids. Both the 3D finned tubes are designed by same parameters and they were tested under the same conditions like inlet velocity, temperature and pressure by using ANSYS fluent software. In the report we were tested the finned tubes according to their fin lengths; 1mm, 1.25mm, and 1.5mm, respectively. The properties of the air and liquid nitrogen fluids were given in the table.4.

Table 4:The Properties of the Air and Liquid Nitrogen Fluids

Properties	Air	Lquid Nitrogen
Density (ρ)	1.225 kg/m^3	806.08 kg/m^3
Specific heat (c_p)	1006.43 J/kg-k	2041.5 J/Kg-k
Thermal conductivity (K)	0.0242 W/m-k	0.14581 W/m-k
Viscosity	1.789*10^{-5} Kg/m-s	0.00016065 Kg/m-s
Inlet temperature (T_{in})	423 k	423 k
Inlet Velocity (u_{in})	2 m/s	2 m/s

Results of 3D Rectangular Finned Tube

The results have been calculated by passing fluids (air and liquid nitrogen) through the 3D rectangular and 3D triangular finned tube bank, and then the velocity has been calculated and the thermal distribution along with the finned tube banks were found and compared these results with the both rectangular and triangular finned tube banks. These results are mainly

depending upon the length of the finned banks, 1mm, 1.25mm and 1.5mm, respectively. Complete fluid analysis has been done by using simulation software only. There no practical experiments, but the accuracy of the results were compared with the previous practical reports [36].

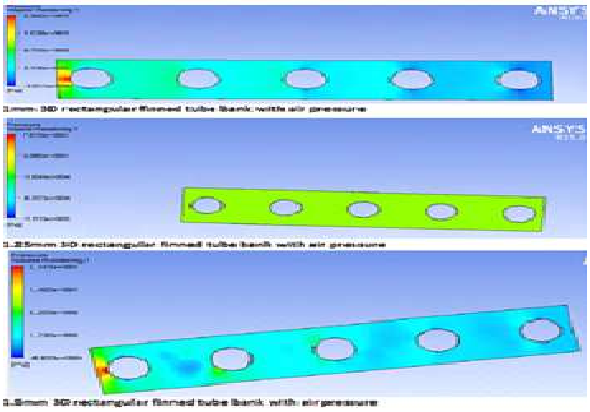


Figure 8 (a): Pressure Variation Results.

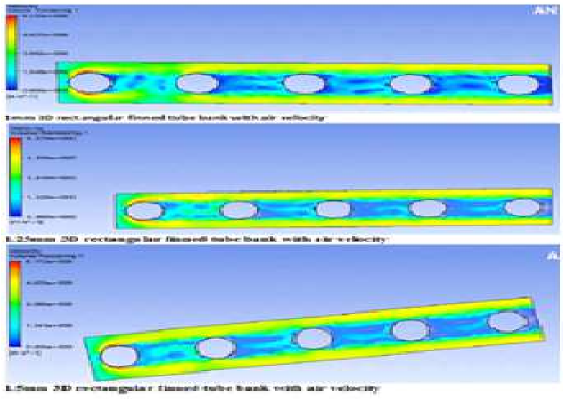


Figure 8 (b): Velocity Variation Results.

Figure 8(a) shows the pressure variations of air in the 3D rectangular finned tube bank. Results were depending upon the fin lengths, 1 mm 1.25 mm, 1.5 mm, respectively. Results are very accurate to clearly observe the pressure variation in the 3D rectangular finned tube bank, by seeing the color variation at the different zones (initial zone, middle zone, end zone), we can judge the pressure results in finned bank with this pressure results. In this result, air pressure was not mostly effective with 3D rectangular finned tube bank. Then Figure 8(b) shows the air velocity variations in the 3D rectangular finned tube bank. In these results, we can clearly say that the velocity distribution of 1 mm 3D rectangular fin with air velocity has been given acceptable results but we would conclude after comparing with the liquid nitrogen results.

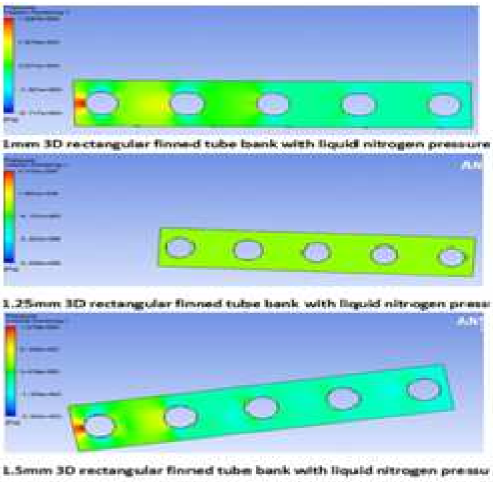


Figure 9 (a): Pressure with Liquid Nitrogen.

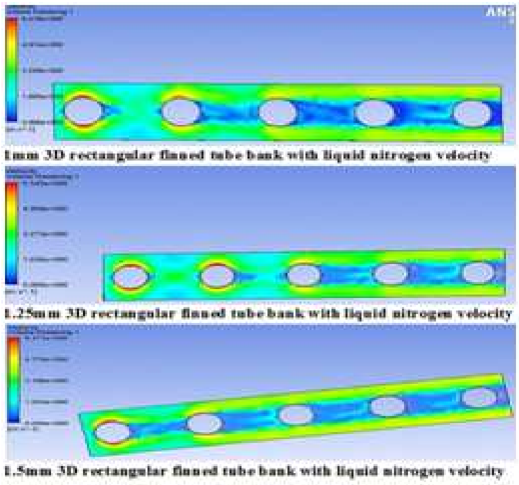
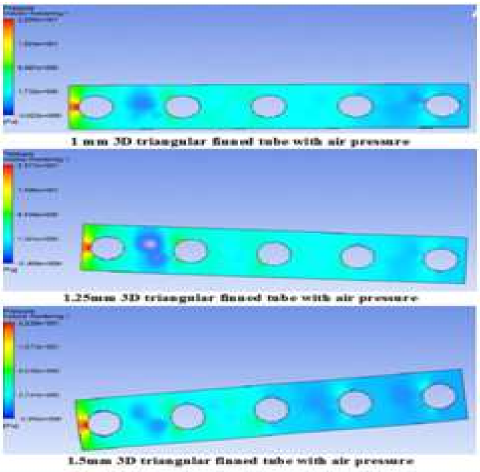


Figure 9 (b): Velocity Variation with Liquid N2.

Figure 9(a) shows the pressure variation results of the 3D rectangular finned tube bank, when we used liquid nitrogen as a fluid. There is no much difference between pressure results whatever the fluid is used i.e. air and liquid nitrogen. In the three cases (1 mm, 1.25 mm, 1.5 mm) depending upon fin lengths, the 1 mm 3D rectangular finned tube bank has given better results it means that at 1mm length of the finned tub bank has less pressure at the finned zones, So that, the temperature at that zone must be less as compared to the other (1.25mm, 1.5mm) lengths of the finned tub e banks. Velocity distribution results were also good at 1 mm 3D rectangular finned tube bank. As of now we concluded that in the

3D rectangular finned tube bank according to simulation results 1mm fin has given good results, then the final conclusion mainly depends upon the comparison of the better 3D rectangular finned tube with better 3D triangular finned tube. For achieving these results we have done lots of trail experiments in the ANSYS fluent software.

Results of 3D Triangular Finned Tube



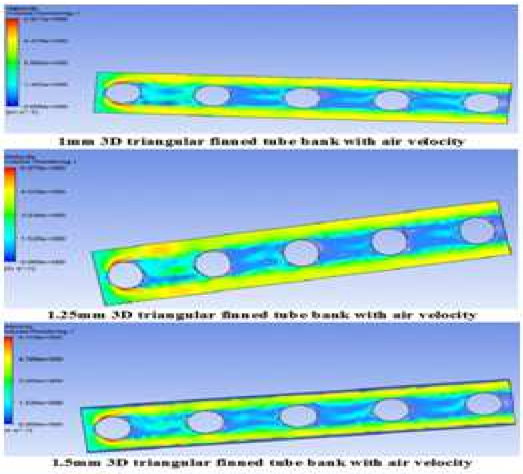
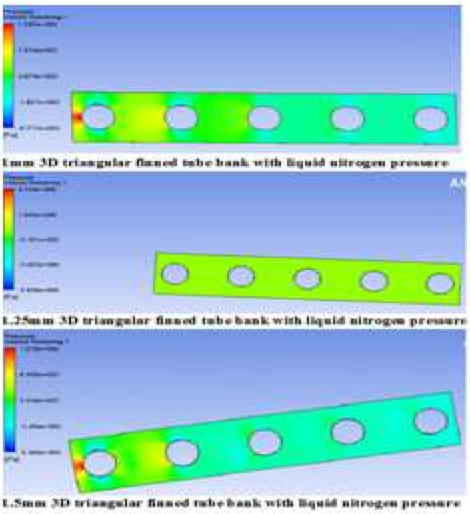


Figure 10 (a): Pressure Variation with Air. **Figure10 (b): Velocity Variation with Air.**

Figure 10 (a) shows the pressure variation results while using air as a fluid flow in the 3D triangular finned tube bank. In this time also 1mm triangular finned tube has given good results while comparing with the 1mm 3D rectangular finned tube bank, here also it has given better then 3D rectangular finned bank. From the Figure 10(b), we can conclude the velocity distribution. In this Figure 9(b) we can surly say that length 1.25mm 3D rectangular finned tube bank has given good results but we have to conclude this results with liquid nitrogen flow.



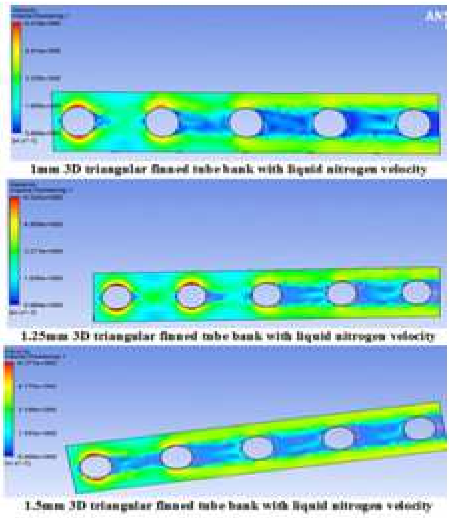


Figure 11 (a): Pressure Variation with Liquid N_2. **Figure 11 (b): Velocity Variation with Liquid N_2.**

Figure 11(a) and (b) shows the results of pressure and velocities, respectively. In these results we have used liquid nitrogen as a fluid. Throughout all the results of 3D rectangular and 3D finned tubes, a 1mm length finned tube has given better results. Compared to the 3D rectangular finned tube bank with 3D triangular, a 1mm 3D triangular finned tube has been given very good results throughout the heat distribution of the heat exchanger.

CONCLUSIONS

- In this research, the rectangular fins and triangular fins were designed by using cad tool creo-2.0 and then performed the flow analysis on both models by using cae tool (Ansys fluent).
- The heat transfer and flow characteristics of triangular and rectangular finned tube bank were investigated numerically.
- The performance of the triangular and rectangular finned tube bank was compared. The effects of fin height on pressure and velocity of air and nitrogen liquid flows are studied to analyze which flow or model can increase the heat transfer coefficient of the finned tube heat exchanger.
- Here each model was designed with 3 finned (1mm,1.25mm,1.5mm) dimensions and applied same boundary conditions for each case, first we calculated results for air, then after nitrogen liquid from the results, rectangle model with 1mm fin has the highest velocity (6.183m/s) compare to all other designs, from the results of nitrogen liquid rectangle model with 1.25mm fin has higher velocity (6.545m/s) and also it has huge pressure (4.116 MPa) on it which is not suggestible, so go with second highest velocity model triangular 1mm fin has 6.5m/s velocity and pressure (1.28e4 Pa) only on it.
- Hence it can be concluded that the triangular 1mm length fin with nitrogen liquid is better than other to enhance the performance of the model.

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